IMU tag v1.0 User Manual
Revision v1.1

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1. Product overview

The IMU tag v1.0 is a small, low powered, inertial/magnetic data logger capable of logging sensor data to an on-board micro SD card and streaming sensor data directly to a computer in real-time via Bluetooth. Sensor data is easily interpreted by any user software as it is represented as comma-separated text values. The device was originally developed to enable the ambulatory monitoring of a patient's motion for a medical research project.

This device requires a regulated 3.3V power supply and provides 'raw' un-calibrated sensor measurements.

1.1. Features

Sensors:

- 16-bit resolution triple-axis accelerometer (±3 g)
- 16-bit resolution triple-axis gyroscope (±1200 º/s)
- 12-bit resolution triple-axis magnetometer (±1 Gauss)
- 16-bit resolution temperature sensor
- 5× 12-bit resolution single-ended analogue inputs (0 to 3.3 V)

Data interfaces:

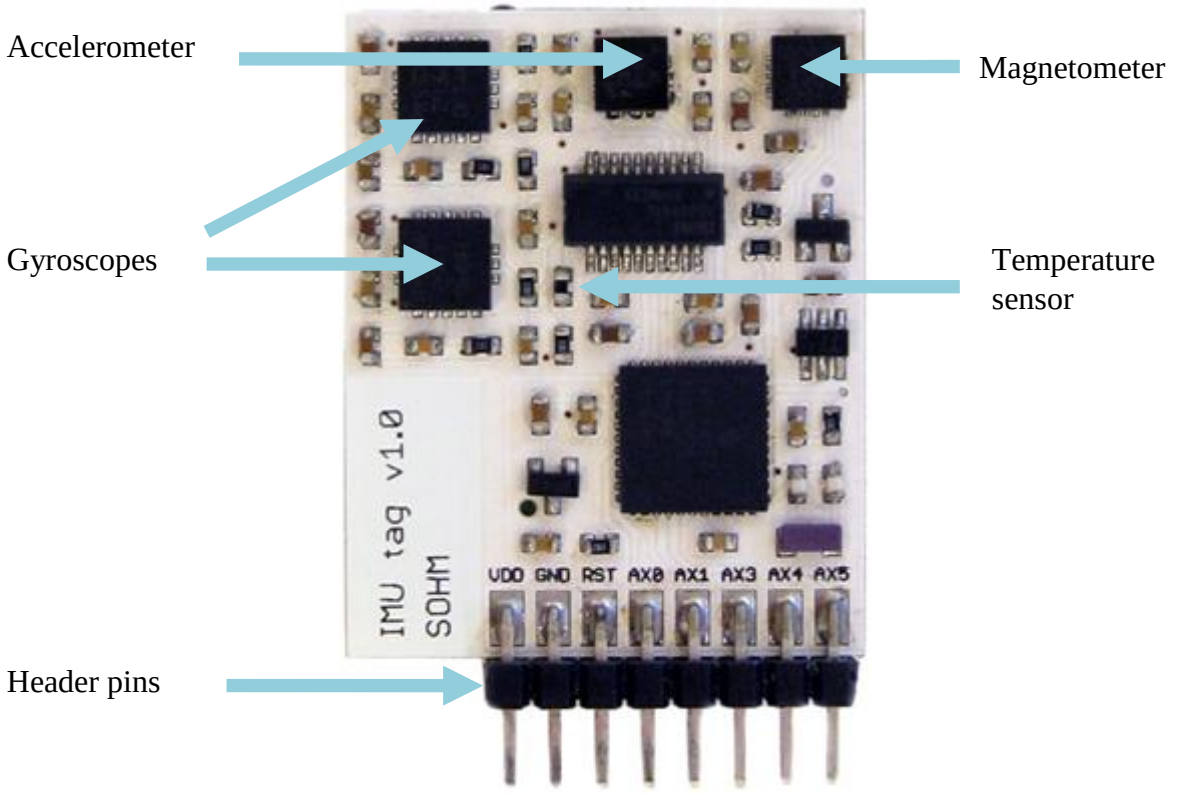
- Class I Bluetooth radio, SPP, 115.2 kbps
- Micro-SD card, FAT12, FAT16 and FAT32 support

Power saving:

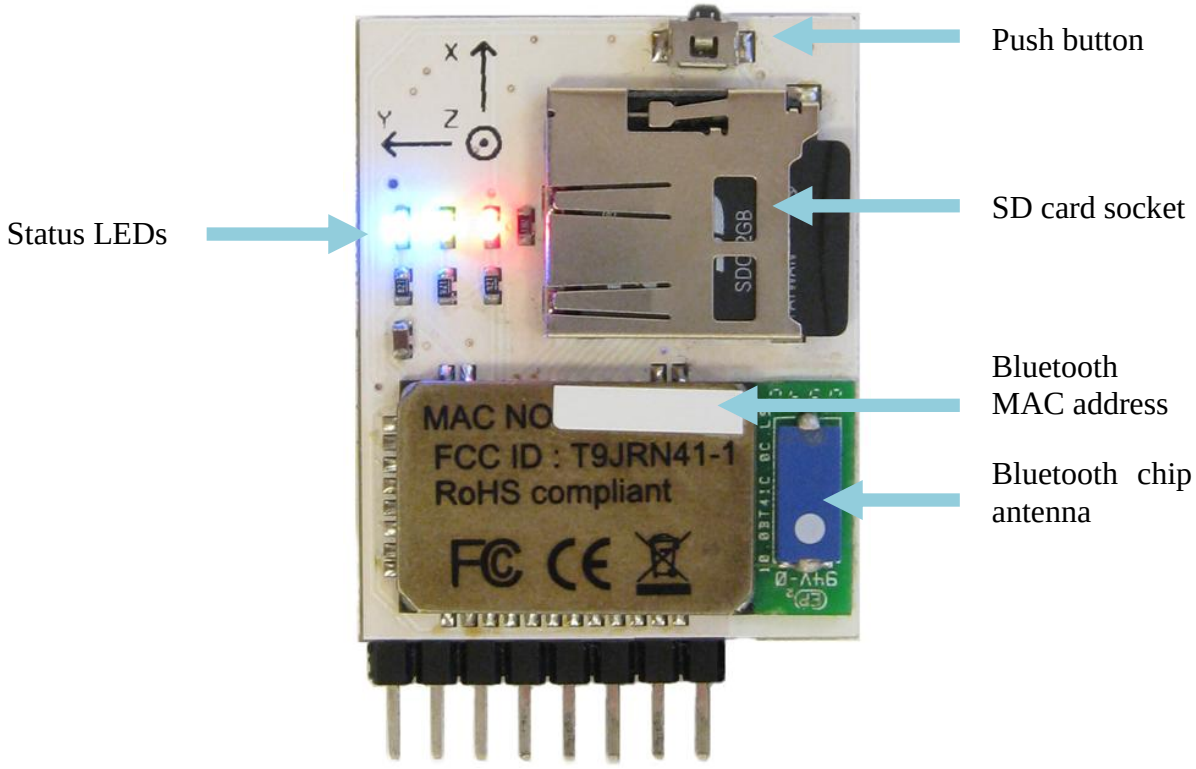
- Device motion trigger wake-up and Sleep timer
- Bluetooth may be turned off or put on sleep timer
- Un-used sensors may be disabled to conserve power
- Data may be represented in hexadecimal to reduce SD card and Bluetooth data rates

2. Hardware and connections

2.1. PCB Top side



2.2. PCB Bottom side



2.3. Connections

Header Pin	Description
VDD	Power supply input: 3.3 V (minimum: 3 V, maximum 3.3V)
GND	Power supply input: Ground
RST	RESET (pull low to reset unit, RTCC will not be reset)
AX0	Analogue input 0 (0 to 3.3V analogue signal)
AX1	Analogue input 1 (0 to 3.3V analogue signal)
AX2	Analogue input 2 (0 to 3.3V analogue signal)
AX3	Analogue input 3 (0 to 3.3V analogue signal)
AX4	Analogue input 4 (0 to 3.3V analogue signal)

2.4. Status LEDs

LED	Description
Blue	Bluetooth power and connection state
Green	Logging state; on while logging
Red	SD card state

2.5. Button behaviour

Action	Behaviour
Press & release	Reset device and start new logging session. If device is asleep it will wake up first.
Press & hold	Terminate logging session and put device to sleep. If device is asleep, it will wake up and force Bluetooth power until button is released.

3. Bluetooth

The IMU tag v1.0 features a Class I (100 m range) Bluetooth radio. The unit operates as a Bluetooth slave with a SPP (Serial Port Profile) and is so recognised by a host (e.g. UAB dongle) as a COM port with a baud rate of 115.2 kbps.

3.1. Connect to the IMU tag v1.0 via Bluetooth

A Bluetooth host may achieve a connection with the IMU tag v1.0 through a standard Bluetooth paring process. This is a straightforward process that will be facilitated by the software wizard associated with the Bluetooth host device or OS. The IMU tag v1.0 will be recognised by other Bluetooth devices by its name and may be connected to using its predefined paring code.

Name: IMU tag v1.0 - < last characters of the devices MAC address>
Paring code: 1234

If the Bluetooth radio is turned off in user the IMU tag v1.0 config Menu or its sleep timer expired before a connection can be made; the user can force Bluetooth radio be remain powered by not releasing the button when waking the IMU tag v1.0 up from sleep. The user may then achieve a connection, after which the button can be released.

3.2. Data transmission

Once connected (i.e. COM port is opened by host), the IMU tag v1.0 will wait 3 seconds before transmitting data. See section 5 for details on interpreting data.

The Bluetooth bandwidth is limited to 115.2 kbps, this is not sufficient to transmit the data for all sensors and inputs in decimal format at the maximum sampling rate (256 Hz). The user may reduce to data throughput to be less than 115.2 kbps by: disabling sensors, reducing sampling rate, or using a hexadecimal data representation.

3.3. Bluetooth LED (Blue)

The blue LED indicates the Bluetooth radio state as summarised in the table below:

LED state	Bluetooth state
Off	Not powered and not connected
Flashing	Powered and not connected
On	Powered and connected

3.4. Bluetooth sleep timer

The Bluetooth may be set in the IMU tag v1.0 config Menu to: “off”, “auto-off (10 s)”, "auto-off (60 s)", "on”. The time period represents how long the Bluetooth radio will remain powered without a connection before turning off. If connected, the Bluetooth radio will not turn off.

4. SD card

The IMU tag v1.0 features a micro-SD card socket for data logging. Each time the IMU tag v1.0 is powered, reset or wakes-up, a new file is created on the SD. File names are numbered absolutely between “00000” and “65535” and will increment; once the file name exceeds “65535” it will start from “00000” again. The file extension (either `.txt` or `.csv`) may be selected in the IMU tag v1.0 config menu; see section 6 for details.

If the SD card or power supply is removed from the IMU tag during logging, then the file being logged to will be empty. The user should be sure to either reset the IMU tag v1.0 at the end of a desired logging period or to put the device to sleep.

4.1. SD card LED (Red)

The red LED indicates the SD card state. The LED is lit each time the SD card is accessed. At high data-rates the LED will flash rapidly, at low data-rates the LED will blink infrequently.

5. Interpreting data

The data saved to the SD card and streamed over Bluetooth is identical. All data is in ASCII and a CSV format. At the start of each logging session a header is transmitted containing the

time, date, sampling rate and enabled sensors. While logging, each sample is represented by a CSV row terminated with "\r\n". An example header and first 20 samples are shown below.

```
date (dd-mm-yy),23-08-10
time (hh-mm-ss),17-08-37
sample rate (Hz),64
sample,acc_x,acc_y,acc_z,gyr_x,gyr_y,gyr_z,mag_x,mag_y,mag_z,therm,ax_0,ax_1,ax_2,ax_3,ax_
4
00000,26719,31372,33220,24654,41070,41317,3042,1472,2369,47392,0018,0018,0015,0017,0018
00001,26592,31749,33056,24670,41071,41381,3082,1453,2386,47369,0016,0018,0018,0017,0017
00002,26679,31407,32932,24683,41052,41343,3067,1496,2374,47374,0018,0018,0018,0017,0018
00003,26641,31484,33282,24661,41045,41341,3075,1452,2390,47377,0017,0018,0018,0017,0022
00004,26636,31426,33339,24648,41036,41345,3055,1490,2376,47386,0018,0019,0018,0016,0018
00005,26617,31536,33128,24670,41052,41332,3046,1470,2367,47391,0018,0019,0018,0017,0018
00006,26680,31634,32893,24651,41064,41365,3080,1454,2384,47381,0018,0018,0018,0016,0017
00007,26704,31363,33199,24679,41043,41350,3057,1504,2373,47386,0017,0018,0018,0017,0016
00008,26676,31516,33270,24638,41072,41354,3073,1464,2383,47383,0018,0019,0018,0017,0017
00009,26679,31593,33321,24653,41048,41326,3053,1502,2379,47381,0018,0019,0019,0017,0018
00010,26638,31685,33098,24671,41072,41377,3049,1473,2368,47376,0017,0018,0018,0017,0018
00011,26725,31489,32916,24654,41080,41320,3072,1458,2380,47386,0018,0017,0017,0018,0017
00012,26692,31142,33325,24667,41052,41333,3060,1495,2372,47382,0018,0018,0018,0017,0014
00013,26580,31347,33118,24644,41080,41336,3046,1466,2363,47385,0018,0021,0019,0017,0018
00014,26640,31487,33250,24615,41093,41378,3059,1499,2375,47372,0018,0018,0018,0017,0018
00015,26634,31648,32823,24615,41142,41432,3040,1469,2365,47351,0018,0019,0018,0017,0018
00016,26730,31206,33222,24631,41090,41350,3069,1455,2374,47380,0018,0019,0018,0017,0018
00017,26616,31410,33298,24617,41095,41390,3064,1506,2372,47362,0018,0018,0018,0016,0017
00018,26618,31407,33240,24633,41064,41335,3041,1466,2359,47382,0017,0018,0018,0017,0018
00019,26602,31672,33146,24637,41089,41403,3070,1455,2381,47359,0018,0019,0019,0018,0018
00020,26739,31612,32904,24601,41130,41430,3069,1462,2354,47349,0018,0019,0018,0017,0018
```

6. IMU tag v1.0 config Menu

The IMU tag v1.0 config menu may be accessed using the Bluetooth connection and any serial terminal software; e.g. HyperTerminal, which is a part of windows XP. If the serial terminal software is connected to the IMU tag v1.0's COM port, the incoming data will be visible on the screen. The menu is accessed by sending the character "**m**". Upon reception, the IMU tag v1.0 will stop logging and send back the text that makes up the IMU tag v1.0 config menu as shown below (with default settings).

```
****************************************
IMU tag v1.0 config menu
****************************************
s - save and reset

General:
0 - sample rate           64 Hz
1 - data format           decimal
2 - file extension        txt
3 - bluetooth             off

Real time clock:
4 - date (dd-mm-yy)       00:00:00
5 - time (hh-mm-ss)       00:00:00

Sensors:
6 - accelerometer         enabled
7 - gyroscope             enabled
8 - magnetometer          enabled
9 - thermistor            enabled
a - auxiliary inputs      enabled

Motion trigger:
b - sleep timer           off
c - wake up threshold     off
****************************************
```

The menu is navigated using single characters displayed on the left. Received data is buffered so that user software may adjust settings quickly; for example: sending the string "m4123456s" will (1) enter the menu, (2) select the time, (3) set the time as 12:34:56, and (4) save the reset.